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Evaluation of the performance characteristics, nutrient digestibility and carcass quality of broiler chickens fed *Lacto acidophilus*® as a replacement for a commercial antibiotic

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Abstract

An experiment was conducted to evaluate efficacy of Lacto acidophilus on the growth performance, carcass characteristics and nutrient digestibility of broiler chickens. Two hundred and twenty five (225), one day old chicks were purchased from local commercial hatchery and were randomly divided into 5 groups and each group had 3 replicates of 17 chicks in a completely randomized design. Five iso-caloric and iso-nitrogenous (ME 2998kcal/ kg and CP 23.21%) broiler starter and finisher (ME 2990 kcal/ kg and CP 20.33%) experimental diets containing 0, 150, 200 and 250g Lacto acidophilus® for T1-T4 respectively and T5 containing Oxytetracycline were formulated. Broiler starter and finisher diets were fed from 0-3 and 4-7 weeks, respectively. Data obtained were subjected to analysis of variance using Statistical Analysis System and significant differences between treatments means were separated using Duncan Multiple Range Test. There were significant (P<0.05) difference in final weight, weight gain, average daily weight gain (ADWG), total feed intake (TFI), average daily feed intake (ADFI), feed conversion ratio (FCR) and feed cost/kg gain across the treatment groups. It was observed that chickens fed dietary Oxytet (oxytetracycline) had the best results in terms of the final body weight, weight gain and ADWG but similar to those fed 150 and 200g Lacto acidophilus® addition levels. The percentage dry matter (DM), crude protein (CP), crude fibre (CF), ether extracts (EE) and ash retention increased with increase in Lacto acidophilus® inclusion with exception for 250gLacto acidophilus® inclusion (CP, CF, EE). However, it was observed that chickens fed dietary levels of Lacto acidophilus® had the best live weight, dressed weight and dressing percentage compared to the control group. It was concluded that chickens fe Lacto acidophilus® inclusion may as well compete favorably with antibiotics growth promoter fed chickens.

Key words: antibiotic, probiotics, growth, carcass characteristics, poultry

L'Évaluation des caractéristiques de performance, de la digestibilité des éléments nutritifs et de la qualité de la carcasse des poulets de gril nourris à l'acidophilus Lacto®comme substitut à l'antibiotique commerciale

Résumé

Une expérience a été menée pour évaluer l'efficacité de Lacto acidophilus sur la performance de croissance, les caractéristiques de la carcasse et la digestibilité nutritive des poulets de gril. Deux cent vingt-cinq (225), poussins d'un jour ont été achetés à l'écloserie commerciale locale et ont été répartis au hasard en 5 groupes et chaque groupe avait 3 répliques de 17 poussins dans une conception complètement randomisée. Cinq iso-caloriques et iso-azotés (le 'ME' 2998kcal/kg et le 'CP' 23.21%) démarreur et finisseur de poulet de gril (le 'ME' 2990 kcal/kg et le 'CP' 20.33%) des régimes expérimentaux contenant respectivement 0, 150, 200 et 250 g d'acidophilus lacto® pour le T1-T4 et le T5 contenant de l'Oxytetracycline ont été formulés. Les régimes d'entrée et de finisseur de poulet de gril ont

été alimentés de 0-3 et 4-7 semaines, respectivement. Les données obtenues ont fait l'objet d'une analyse de la variance à l'aide du système d'analyse statistique et des différences significatives entre les moyens de traitement et ils ont été séparées à l'aide du test à distance multiple Duncan. Il y avait une différence significative (P<0,05) dans le poids final, le gain de poids, le gain de poids quotidien moyen (le 'ADWG'), la consommation totale d'aliments pour animaux (le 'TFI'), l'apport quotidien moyen en aliments pour animaux (ADFI), le ratio de conversion des aliments pour animaux (FCR) et le gain coût/kg des aliments pour animaux dans les groupes de traitement. On a observé que les poulets nourris oxytet alimentaire (oxytetracycline) ont eu les meilleurs résultats en termes de poids corporel final, gain de poids et de 'ADWG', mais similaire à ceux nourris 150 et 200g Lacto acidophilus® niveaux d'addition. Le pourcentage de matière sèche (le 'DM'), de protéines brutes (le 'CP'), de fibres brutes (le 'CF'), d'extraits d'éther (le 'EE') et de rétention de cendres a augmenté avec l'augmentation de lacto acidophilus® l'inclusion à l'exception de 250 glacto acidophilus® inclusion (CP, CF, EE). Cependant, il a été observé que les poulets nourris à des niveaux alimentaires de Lacto acidophilus® avaient le meilleur poids réel, le poids habillé et le pourcentage de vinaigrette par rapport au groupe témoin. Il a été conclu que les poulets feLacto acidophilus® inclusion peut aussi bien rivaliser favorablement avec les antibiotiques promoteur de croissance nourris poulets.

***Mots clés**: antibiotiques, probiotiques, croissance, caractéristiques de la carcasse, volaille*

Introduction

The abuse of antibiotic growth promoters has become a global issue in animals and humans well being. However, antibiotics growth promoters' usage cannot be completely banned as it could be useful without abuse. There have been studies on alternative use of feed additives either natural or synthetic in poultry feeds to improve weight gain, feed efficiency and to decrease mortality rate (Nawaz *et al*., 2016). Probiotics are classified as live non-pathogenic microorganisms that are capable of maintaining a normal gastrointestinal microbiota (Patterson and Burkholder, 2003). Commercially produced probiotics can contain one or many strains of microbial species, with the more common ones belonging to the genera *Lactobacillus*, *Bifidobacterium*, *Enterococcus*, *Bacillus* and *Pediococcus* (Gaggia *et al.,* 2010). However, the overall importance of the use of probiotics in poultry feed is to digest, absorb nutrients and to produce a well-balanced microbiota in the gastrointestinal tract which is crucial for optimal animal health and performance (Ritzi*et al*., 2010). Increasing incidence of antibiotic resistance is considered to be one of the greatest threats to public health globally. Therefore, poultry nutrition studies are gaining more interest in the possibility way of altering the intestinal microbiota in a beneficial and "natural" way to improve animal health thus preventing the need to use antibiotics. Feeding broilers with probiotic *Lactobacilli* is potentially a useful approach to address this global concern. Studies conducted by Tannock (2004) and Zhao *et al.* (2007) showed that *Lactobacilli* become established in the gastro-intestinal (GI) tract of chicks soon after hatching and their metabolic activity lowers the pH of the digesta, which in turn inhibits the proliferation of enterobacteria and other unwanted bacteria. Furthermore, there have been positive results on the inclusion of *Lactobacillus acidophilus* in broiler chickens feed on growth performance, foot pad dermatitis and caecum microbiome. Recent study conducted by De Cesare *et al*., 2020 showed that supplementation with

Lactobacillus acidophilus at the recommended dietary dosage of feed significantly improved body weight at 28 days (commercial weight of 1.5 kg) and feed conversion rate from 0 to 41 days, while reducing the incidence of pasty vent.

Many factors have been associated with the efficacy and modes of action of probiotic *Lactobacilli*, these include, the bacterial strain, the dosage, the duration of the treatment, and the delivery strategy (De Cesare *et al*., 2020). However, seasons of rearing may be a factor to be considered when using probiotics in feeds of broiler chickens. In the present study we explored the dietary effect of supplementing *Lactobacillus acidophilus* on performance, nutrient digestibility and carcass characteristics of broiler chickens reared under tropical condition.

Materials and methods

Experimental site

The experiment was conducted at the Poultry Unit of the Department of Animal Science Teaching and Research farm, Ahmadu Bello University, Zaria, Kaduna State. Zaria is in the Northern Guinea Savannah Zone, located on latitude $11^0$09' 01.78"N, longitude $07^0$39' 14.79"E with an altitude of 671 m above sea level. The climate is characterized by well-defined dry and wet seasons with a mean annual rainfall ranging from 700-1400 mm. Onset of wet season begins in late April or early May, peaks between July and August and ends in mid-October. This is followed by the Harmattan season which comprises of a cold and dry weather. The average minimum and maximum daily temperature varies from 14-24^{0}C during the cold season and 19-38.3^{0}C during the hot season. The relative humidity alternates between 19-35% in the dry season and 63-85% in the wet season, Institute for Agricultural Research (IAR Meteorological Unit, 2018).

Experimental design and management of birds

Two hundred and fifty five (255), Ross broiler chicks of mixed sexes were assigned to five dietary treatments for group brooding of one week after which they were distributed on the basis of similar average weight into three replicates per treatment with 17 birds each in a completely randomized design (CRD). The birds were housed in deep litter pens and all necessary routine management practices were observed. Water and feed were administered ad libitum for the 7 weeks experimental period. All vaccinations/medication were administered as at when due. The diets were isocaloric and isonitrogenous and formulated to meet the nutrient requirements of the broiler chicks during starter and finisher periods (Tables 1) according to the National Research Council requirements (NRC, 1994).

Experimental diets

Diets comprising of five treatments were formulated as shown in Tables 1 with *Lacto Acidophilus*® added in the diets. **T**he *Lacto acidophilus*® used was manufactured by a commercial company (MIAVIT GmbH, Germany) and was purchased from Agricare in Ibadan**.**Treatment 1 was the basal diet (positive control) with neither probiotic nor antibiotic addition. Treatment 2, 3 and 4 comprised of basal diet with 150, 200 and 250 g/100kg *Lacto Acidophilus*® respectively. Treatment 5 contained basal diet with 66 g oxytetracycline (negative control).

Table1: Basal diets composition

Ingredients	(0-3 week)	(4-7 weeks)
Maize	55.40	59.67
Soya bean cake	27.50	21.00
GNC	13.21	12.00
Palm oil	1.50	1.50
Bone meal	2.50	3.00
Limestone	2.50	3.00
Common Salt	0.30	0.30
Methionine	0.30	0.15
Lysine	0.13	0.18
Vit-min-Premix[1]	0.16	0.25
Total	100.00	100.00
Calculated Analysis		
ME (Kcal/kg)	2,998	2,990
Crude Protein (%)	23.21	20.37
Crude Fibre (%)	4.57	4.39
Ether Extract (%)	4.85	4.63
Calcium (%)	1.18	1.35
Phosphorus (%)	0.66	0.75
Methionine (%)	0.86	0.77
Lysine (%)	1.27	1.13

[1]Vitamin mineral premix provide per kg of diet. Vit. A, 13,340 i.u; Vit. D_3, 2680 i.u; Vit. E, 10 i.u; Vit. K, 2.68 mg; Calcium pantothenate, 10.68mg; Vit. $B_{12,}$ 0.022 mg, Folic acid, 0.668mg; Choline choride, 400 mg; Chlorotetracyline, 26.68 mg; manganese, 13 mg; iron, 66.68 mg; Zinc, 53.34 mg; Copper, 3.2 mg; Iodine, 1.86 mg; Cobalt, 0.268 mg; Selenium, 0.108 mg

Growth performance

The initial and final weights of birds were taken at the inception and at the end of the experiment both at starter and finisher phases. Final weight, weight gain, average daily gain, feed intake, feed conversion ratio (FCR) and feed cost (N/ kg gain) were determined on a weekly basis and **FCR was calculated as feed intake/body weight gain**. Mortality was recorded as it occurred.

Carcass analysis

At the end of the 7th week of the feeding trial, three birds from each pen with approximate body weights equal to the mean weight of the birds in the pen were used. They birds were fasted overnight in order to allow for the emptying of the gastro-intestinal tract (GIT) and weighed. The selected birds were slaughtered for carcass analysis by severing the neck with a sharp knife and allowed to bleed completely. They were then defeathered and eviscerated. The liver, gizzard, thigh and breast were weighed and expressed as percentages of the live body weight and the carcass weight respectively. The intestinal length was measured in centimeters.

Statistical analysis

All data obtained from this experiment were subjected to analysis of variance (ANOVA) using the General Linear Model Procedures (GLM) of the Statistical Analysis Software package. Significant difference between treatments means were separated using Duncan Multiple Range Test (SAS, 2001).

Experimental model

$Y_{ij} = \mu + T_i + e_{ij}$

Y_{ij} = performance of j^{th} animal fed i^{th} levels of probiotic inclusion

μ = Overall mean

T_i = i^{th} effect of treatment at varying levels of probiotic inclusion

e_{ij} = Random residual error

Results and discussion

The results of the growth performance of

broiler chickens fed diets containing varying levels of *Lacto Acidophilus*® is presented in Table 2. There were significant (P<0.05) differences in final weight, weight gain, average daily weight gain (ADWG), total feed intake (TFI), average daily feed intake (ADFI), feed conversion ratio (FCR), feed cost/kg gain and mortality rate across the treatment groups. The significant improvement in final weight, weight gain, ADWG, TFI and ADFI of experimental birds (150 and 200g *Lacto Acidophilus*®) compared to the control agrees with the findings of Ohimain and Ofongo (2012) and Ritzi*et al.* (2014) who reported improved growth performances when *Lactobacillus (L.) acidophilus* and *L. casei* isolated from the fermented milk and other probiotic species were used in feed of broiler chickens. In contrast however, the authors observed better feed conversion ratios (Awais*et al.,* 2019) which are not in line with the findings of this study as no significant improvement on the FCR of birds treated with Lacto Acidophilus®. O'Dea *et al.* (2006) also reported significant increase in BW of birds fed a probiotic containing *Lactobacillus acidophilus*, *Lactobacillus bifidus*, and *Enterococcus faecalis,* although FCR was not significantly different. The insignificancy in feed efficiency of probiotics may be due to factors such as: selection of strain, administration level, application method, ability of the selected strain to survive at environmental temperatures, long-term storage and viability (Sinol*et al.,* 2012; Chen *et al.,* 2013). Furthermore, it can be observed that birds fed Oxytetracycline had the best growth performance and feed conversion ratio. This shows that in-feed antibiotic improves weight gain and feed efficiency. This promoting effect of antibiotic could be due to their ability to directly or indirectly inhibit the commensal flora that is in competition with the host animal for nutrients (Van der Klis and Van Eerden, 2002). This study agrees with the report of Moses *et al.* (2017) who evaluated the efficacy of a eubiotic (CRINA® Poultry Plus) as alternative to the conventional antibiotics used as growth promoter discovered that birds on AGP (Oxytetracycline) had higher values for final weight, weight gain and feed consumption at finisher phase. In contrast however, there was no significant improvement on growth parameters of birds fed different level of CRINA® Poultry Plus and feed conversion ratio was not significant (Mountzouris*et al.,* 2007). The authors attributed the improved growth and feed efficiency to the action of microorganism in the intestinal tract. Mortality rate was between 0 to 2 % across the treatment groups. Percentage mortality recorded may not be as a result of the test material but due to sudden death syndrome.

Apparent nutrient digestibility of broiler chickens (7weeks) feddiets *containing varying levels of* ***lacto acidophilus***®

Table 3 shows the effect of feeding varying levels of Lacto Acidophilus® on the apparent nutrient digestibility of broiler chickens. All the parameters measured were significantly (P<0.05) affected by dietary treatments. The percentage dry matter (DM) content of birds fed Lacto Acidophilus® dietary levels (150 g, 200 g, 250 g) and dietary Oxytet were significantly (P<0.05) higher compared to the control. The percentage dry matter (DM), crude protein (CP), crude fibre (CF), ether extracts (EE) and ash retention increased with increase in Lacto Acidophilus® inclusion with exception for 250g Lacto Acidophilus® inclusion (CP, CF, EE). It was observed that chickens fed 200g Lacto Acidophilus® dietary level had significantly high digestibility values while the control had the lowest digestibility across all the parameters measured. The significant increased in the DM and CP digestibility coefficients of this study agrees with the

Table 2: Growth performance of broiler chickens (0-8weeks)fed diets containing varyinglevels of Lacto acidophilus®

	Inclusion Levels of Lacto Acidophilus®					
Parameters	0.0g	150g	200g	250g	Oxytet	SEM
Initial Weight (g/bird)	41.11	41.56	42.22	40.89	41.33	0.00
Final Weight (g/bird)	2388.41^{b}	2426.19^{ab}	2401.65^{ab}	2235.16^{c}	2505.86^{a}	53.64
Weight Gain (g/bird)	2347.30^{b}	2384.64^{ab}	2359.43^{ab}	2194.27^{c}	2464.53^{a}	53.64
ADWG (g/bird/day)	111.78^{b}	113.55^{ab}	112.35^{ab}	104.49^{c}	117.36^{a}	2.55
TFI (g/bird)	4267.20^{b}	4593.10^{a}	4203.40^{b}	3968.50^{c}	4355.90^{b}	102.13
ADFI (g/bird/day)	203.20^{b}	218.72^{a}	200.16^{b}	188.98^{c}	207.42^{b}	4.86
FCR	1.82^{a}	1.93^{b}	1.78^{a}	1.81^{a}	1.77^{a}	0.04
Feedcost/kg gain (₦/kg)	241.56^{a}	264.11^{c}	246.73^{ab}	253.42^{b}	246.74^{ab}	4.74
Mortality (%)	1.67^{a}	0.67^{a}	2.00^{a}	0.00^{b}	0.67^{a}	0.82

a,b,c=Means with different superscript on the same row differ significantly (P<0.05)
ADWG = Average Daily Weight Gain; TFI = Total Feed Intake; ADFI = Average Daily Feed Intake; FC R = Feed Conversion Ratio; Oxytet = Oxytetracycline; SEM = Standard Error of Means

Table 3: Apparent nutrient digestibility of broiler chickens (7weeks)feddiets containing varying levels of Lacto acidophilus®

	Inclusion Levels of Lacto Acidophilus®					
Parameters (%)	**0.0g**	**150g**	**200g**	**250g**	**Oxytet**	**SEM**
Dry Matter	44.80^{b}	56.81^{a}	59.46^{a}	64.00^{a}	59.97^{a}	4.738
Crude Protein	57.35^{b}	61.01^{ab}	66.23^{a}	66.01^{a}	64.62^{ab}	4.239
Crude Fibre	27.33^{b}	32.39^{b}	53.58^{a}	47.69^{ab}	36.33^{b}	8.141
Ether Extract	66.06^{c}	71.49^{b}	77.31^{a}	76.03^{ab}	71.94^{b}	2.320
Ash Retention	17.35^{b}	31.84^{a}	32.86^{a}	36.17^{a}	35.38^{a}	7.552
Nitrogen Free Extract	44.03^{b}	62.32^{a}	57.69^{a}	58.81^{a}	58.14^{a}	5.355

a,b=Means with different superscript on the same row differ significantly (p<0.05)
Oxytet = Oxytetracycline; SEM = Standard Error of Means

findings of Mountzouris*et al.* (2017), who reported that the group supplemented with probiotic showed a significantly higher crude protein and dry matter digestibility coefficients than the control group. This could be as a result of the rapid development of beneficial bacteria in the caeca of the birds thereby creating a convenient environment for efficient digestion and nutrient absorption processes. The significantly higher values of CF and EE of birds fed 200g Lacto Acidophilus® compared to those fed control and oxytet diets could be attributed to the improved metabolism of microbes by increasing digestive enzyme activity and decreasing bacterial enzyme activity and ammonia production. The significant improvement in nutrient digestibility also conforms to previous authors who reported that probiotics improve growth performance and nutrient digestibility, balance intestinal microflora, promote immune function and benefit the intestinal morphology (Sinol *et al.,* 2012; Zhang and Kim, 2013).

Effect of Lacto acidophilus® on carcass characteristics of broiler chickens (7weeks)

The carcass characteristics of broiler chickens fed varying levels of Lacto Acidophilus® are presented in Table 4. There were significant (P<0.05) difference

Table 4: Effect of Lacto acidophilus®on carcass characteristics of broiler chickens (7weeks)

	Inclusion Levels of Lacto Acidophilus®					
Parameters (%)	0.0g	150g	200g	250g	Oxytet	SEM
Live Weight (g/bird)	2450.00^{ab}	2483.30^{ab}	2510.00^{a}	2353.30^{b}	2536.70^{a}	67.03
Dressed Weight (g/bird)	1733.30^{b}	1716.70^{b}	1806.70^{a}	1583.30^{c}	1883.30^{a}	58.86
Dressing Percentage (%)	70.71^{ab}	69.12^{b}	72.03^{a}	67.41^{b}	74.21^{a}	1.81
Prime cuts expressed as percentages of dressed weights						
Thigh	15.21^{b}	15.32^{b}	17.76^{a}	15.43^{b}	17.89^{a}	0.92
Drumstick	12.43^{b}	12.26^{b}	14.12^{a}	12.80^{b}	12.29^{b}	0.80
Breast	28.82^{a}	29.30^{b}	31.82^{a}	28.29^{b}	28.65^{b}	1.56
Back	18.01^{b}	18.08^{b}	21.14^{a}	21.18^{a}	21.12^{a}	0.92
Wing	11.15^{a}	11.73^{a}	11.21^{a}	9.16^{b}	9.72^{b}	0.50
Organs expressed as percentages of live weight						
Liver	2.17	2.13	2.18	1.69	1.80	0.23
Lungs	0.67	0.61	0.48	0.49	0.67	0.11
Kidneys	0.32^{b}	0.18^{b}	0.98^{a}	0.97^{a}	0.32^{b}	0.07
Heart	0.58	0.50	0.53	0.46	0.58	0.09
Gizzard	1.94^{a}	1.86^{a}	1.98^{a}	1.87^{a}	1.58^{b}	0.15
Intestinal length (cm)	279.30^{b}	343.70^{a}	273.30^{b}	271.70^{b}	270.30^{b}	14.38

a,b=Means with different superscript on the same row differ significantly ($p<0.05$)
Oxytet = Oxytetracycline; SEM = Standard Error of Means

in the live weight, dressed weight and dressing percentage across the treatment groups. However, it was observed that chickens fed dietary levels of Lacto Acidophilus® had the best live weight, dressed weight and dressing percentage compared to the control group. The dressed weight and dressing percentage ranged from 1583.3 to 1883.3g/bird and 67.41 to 74.21% respectively with birds fed Oxytet dietary level having the highest dressed weight and dressing percentage while those fed diet containing 250g Lacto Acidophilus® had the lowest dressed weight and dressing percentage. For the prime cuts and organs parameters, dietary treatments had significant ($P<0.05$) effects on the thigh, drumstick, breast, back, wing, kidney, gizzard and intestinal length. The carcass parameters of birds fed Lacto Acidophilus® (200g) and Oxytet supplemented diets were significantly improved in live weight, dressed weight and dressing percentage compared to the control diet. This could be due to the impact of microorganism in feed digestion and nutrient utilization by the host animal resulting to improvement in weight gain. The significant effect of 200g Lacto Acidophilus® treatment compare to control in the live weight, dressed weight and dressing percentage is in line with the findings of Mahajan *et al.* (1999) who recorded significantly higher mean values of dress weight and dressing percentage in probiotic (Lacto-Sacc) fed broilers. Likewise, Kioumarsi*et al.* (2012) who reported significant differences in dress weight, dressing percentage, breast muscle, thigh drumstick, heart, gizzard and liver of the broilers fed probiotics compared to those of the control. In contrast however, there was no significant improvement in drumstick, breast, liver and gizzard. However, treatment group fed 200g Lacto acidophilus®were similar to the control

group in terms of thigh, breast and back weights.

Conclusions

The results of the present study showed that dietary supplementation of *Lactobacillus acidophilus* in broiler ration can compete favourably with antibiotic supplemented diets to improve growth performance, carcass characteristics and functional nutrient digestibility of broiler chickens. However, further studies should be conducted to determine the optimum level of *Lactobacillus acidophilus* inclusion in broiler ration.

Conflict of interest statement

The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

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